Quality Assurance Plan

For the

Neutrinos at the Main Injector (NuMI) Project

Revision 2.4

May 8, 2000

Approvals:

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NuMI Project Manager	Date
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NuMI Project Mechanical Engineer	Date
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NuMI Project Electrical Engineer	Date
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NuMI Quality Assurance Coordinator	Date

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List of Abbreviations

A/E	Architectural & Engineering
ANSI	American National Standards Institute
BD	Beams Division (Fermilab)
BSS	Business Services Section (Fermilab)
CD	Critical Decision
CSP	Cost & Schedule Plan
DOE	Department of Energy
ES&H	Environment, Safety & Health
FESHM	Fermilab ES&H Manual
FESS	Facilities Engineering & Services Section (Fermilab)
ISO	International Standards Organization
L1	Level 1 (of WBS)
L2	Level 2 (of WBS)
L3	Level 3 (of WBS)
MINOS	Main Injector Neutrino Oscillation Search
MOU	Memorandum of Understanding
NIST	National Institute of Standards & Technology
NuMI	Neutrinos at the Main Injector
OPC	Other Project Costs
PAC	Physics Advisory Committee
PEP	Project Execution Plan
PMP	Project Management Plan
PPD	Particle Physics Division (Fermilab)
PSAD	Preliminary Safety Assessment Document

QA	Quality Assurance
R&D	Research and Development
SAD	Safety Assessment Document
TDR	Technical Design Report
TEC	Total Estimated Cost
URA	Universities Research Association, Inc.
WBS	Work Breakdown Structure

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Introduction

Quality Assurance (QA) is an integral part of the design, procurement, fabrication, construction and installation of the Neutrinos at the Main Injector (NuMI) Project. This document describes how quality assurance is implemented in the NuMI Project. The goal of this QA Plan is to document the program by which the NuMI Project will produce the facilities and apparatus for NuMI within the technical scope, cost and schedule specifications as described in the referenced documentation.

The management of the NuMI Project will be in conformance with DOE Order 430.1, *Life Cycle Asset Management.* This Plan has been developed using the implementation guidance for that order.[1] It addresses 10 quality-related criteria, which are organized into three functional groups: Management, performance and assessment. This plan is implemented throughout the NuMI Project using a graded approach, that is, the degree of QA planning and documentation should be commensurate with the cost and complexity of any given subsystem of the project. Furthermore, QA for the NuMI Project is conducted in accordance with the Fermilab Director's Policy on Quality Assurance.[2]

The multi-faceted nature of the NuMI Project, which includes the construction of a beamline, experimental facilities off-site and experimental detectors, calls for management and QA processes that are flexible enough to meet the requirements of these different subprojects. The project management responsibilities also reflect the project's budget structure, for which the Total Estimated Cost (TEC) includes the civil construction and technical components of the NuMI beamline. The MINOS detectors

and work at Soudan are funded as Other Project Costs (OPC). The sum of the TEC and the OPC is the Total Project Cost (TPC).

Work on the beamline technical components will be accomplished mainly by Fermilab personnel and subcontractors in conformance with Fermilab's QA requirements, with a relatively small amount of the work performed by other research institutions.

Civil construction and outfitting of the NuMI tunnels and halls at Fermilab will be done by subcontractors experienced in such work. Each major subcontractor will submit his own QA plan to ensure conformance with Fermilab's QA requirements.

By contrast, much of the work on the MINOS Subproject will be accomplished by the various institutions of the MINOS collaboration. This work is described in detail in Memoranda of Understanding between Fermilab and the collaborating institutions. The specific QA processes for MINOS are defined largely within the collaboration in conformance with Fermilab's QA requirements.

Construction and outfitting at the Soudan Underground Laboratory will be performed under an agreement with the University of Minnesota.

Hence, the QA processes are somewhat different for each of the major NuMI subprojects. In the following sections of this document, which describe how the NuMI project meets the QA criteria cited above, processes and documentation that are particular to the individual major subprojects will be specified as appropriate.

Project Phases and Critical Decisions

The project is considered to proceed in four phases: Preconceptual Activities, Conceptual Phase, Execution Phase, and Closeout Phase. In each of these phases, a critical decision (CD) is made which enables the project to proceed. These are, respectively, Approval of Mission Need, Approval of Project Baseline, Start of Project Construction, and Project Completion (Start of Operations).

The Department of Energy (DOE) issued CD-1 on March 5, 1997.[3] CD-2, Approval of the NuMI Baseline, was issued on February 17, 1999, via the NuMI Project Execution Plan (PEP), which describes the management systems employed by DOE in the NuMI Project.[4] The project is presently in the Execution Phase. The third critical decision was issued in two parts: CD-3A, which approved the start of construction activities at the Soudan Mine[5], and CD-3B, which approved the start of construction activities at Fermilab.[6]

Environment, Safety and Health (ES&H) matters are a primary consideration for the NuMI Project. An important part of the project's conceptual phase was an Environmental Assessment,[7] which resulted in a Finding of No Significant Impact.[8] The NuMI Project Staff has also developed a Preliminary Safety Assessment Document (PSAD).[9] The purpose of this document is to identify the potential ES&H hazards for the NuMI Project. The specific methods of addressing the hazards identified in the PSAD will be detailed in the Safety Assessment Document (SAD). The University of Minnesota in accordance with an MOU between the University of Minnesota and Fermilab assumes responsibility for ES&H at the Soudan Mine site.[10] The University of Minnesota has developed a separate safety assessment for the Soudan Mine site.[11]

Management Criteria

This section specifies the management criteria for quality assurance in the NuMI Project. These criteria include program elements, personnel training and qualification, quality improvement and control of documents and records.

Criterion 1: Program

This QA Plan constitutes the primary Quality Assurance document for the NuMI Project and is maintained by the NuMI Quality Assurance Coordinator. While describing the fundamentals of Quality Assurance for the NuMI Project, it also serves as a directory to other documentation, which provides programmatic definition for the NuMI Project. As described in the NuMI Project Management Plan (PMP),[12] the NuMI Project is comprised of a diverse set of activities and this document will not attempt to give a detailed description of QA implementation for each element of the project. Instead, such details will be provided in other documents that are referenced or included as attachments. Quality Assurance Plans prepared by subcontractors and Advance Acquisition Plans are examples of such documents.

This QA Plan is reviewed annually and updated as necessary. Revisions of the QA Plan are reviewed by the NuMI Project Management Team, as defined in the PMP, and by Level 1 Project Managers. Revisions are approved by signatures of the NuMI Project Manager, the NuMI Project Engineers (mechanical and electrical), and the NuMI QA Coordinator. A revision history is included at the end of this document.

Project Description

A Summary Document[13] provides a concise overview of the NuMI Project. This document is updated at approximately six-month intervals. A more detailed description of the project is given in other documentation. The Technical Design Reports (TDRs) define the scope of the NuMI beamline and facilities to be built at Fermilab, the detectors for the MINOS experiment and the construction and outfitting of facilities in the Soudan Underground Laboratory. Additional and updated information is documented in the monthly project reports and NuMI Notes. Details of the cost and schedule for the NuMI Project are given in the Cost & Schedule Plan.[14]

NuMI Beamline

Preliminary descriptions of this portion of the NuMI Project are given in the Conceptual Design Report[15] and a Technical Design Report (TDR).[16] These documents are supplemented with a Value Engineering Study.[17] As the project evolves, a current detailed description is maintained in the NuMI Beam Design Handbook.[18]

MINOS Detectors

The baseline scope of this portion of the NuMI Project is described in detail in a TDR.[19] The organization and management practices for the MINOS Collaboration are specified in the MINOS Management Plan. This document is maintained by the MINOS Institutional Board, which is the ultimate authority for all collaboration matters. The MINOS Institutional Board also maintains the MINOS Organization Document, which is a summary of MINOS committees and working groups, and the Collaboration Membership list.

Soudan Experimental Hall

A detailed description of this portion of the NuMI Project is given in a TDR[20] and in a Design Criteria Document.[21]

Project Organization

The basic organizational structure, functional responsibilities, levels of authority and management processes and interfaces are described in two project management documents. The NuMI PEP describes the DOE management structure for the project and establishes the technical, cost and schedule baseline. The NuMI PMP sets forth the plans, organization and management systems used by Fermilab. The NuMI Project Manager maintains the PMP, with approval from the DOE. The PMP defines the Project Management Group, the Project Management Team, and subproject managers, along with their roles and responsibilities. The PMP outlines the organization to Level 3 of the Work Breakdown Structure (WBS) for the TEC (civil construction at Fermilab and beamline) and to Level 2 of the WBS for the OPC. Additional details of the organization of major elements of the NuMI Project are described below. The NuMI Project Fermilab staff includes members of Fermilab's Beams Division (BD) and Particle Physics Division (PPD).

NuMI Beamline

Design, construction and installation of the technical components of the NuMI beamline is undertaken primarily within the purview of the Fermilab Beams Division. Where collaborating institutions participate in this element, work is performed under Memoranda of Understanding (MOU) or similar documents.

In addition to the services provided by Fermilab's Facilities Engineering Services Section (FESS), Architectural/Engineering Title I, II and III civil construction services at Fermilab will be obtained from Fluor Daniel/Harza Engineering and CMT for architectural services. Major subcontractors are required to have a QA Plan, subject to review and audit by Fermilab.

MINOS Detectors

The MINOS detectors are built primarily by the various institutions of the MINOS collaboration. The interfaces and responsibilities of the various participants are further defined in an MOU with each participating institution. The MOU represents an understanding between Fermilab and the collaborating institution regarding their respective responsibilities in the NuMI Project. These agreements are intended to utilize the expertise and facilities of collaborating institutions as efficiently as possible to further the goals of the project.

Soudan Experimental Hall

Organizational details of this part of the NuMI Project are given in the MOU between Fermilab and the University of Minnesota.

Management Systems

The PMP includes descriptions of management systems applied to the NuMI Project, including reporting requirements, project monitoring & earned-value assessment, change control management, contingency management, and cost & schedule management.

Criterion 2: Personnel Training and Qualification

It is the policy of the NuMI Project to employ personnel, in all facets of the project, who possess the appropriate level of skills, experience and academic qualifications to support the project.

NuMI Beamline

Fermilab personnel, including scientists, engineers, and project support staff, are trained and qualified in accordance with the standards of the Laboratory. In-house training is provided to insure that an appropriate level of skills, knowledge, expertise, and experience are available to complete the NuMI Project. Job-related training records of all Fermilab personnel, for work related to the NuMI project, are maintained by the appropriate department. ES&H-related training is provided to all participants in NuMI Project work, commensurate with the hazards associated with the work performed. Fermilab maintains a database of the training received by Fermilab personnel and visitors. As necessary, Fermilab personnel receive training from off-site experts for work specific to NuMI, e.g., underground emergency response or inexperienced miner training.

Subcontractors performing work for NuMI will be required to provide properly trained and qualified personnel as part of their subcontract. This is particularly important for underground construction work. Experience in underground construction is a pre-qualifying condition for subcontractors engaged in such work. Fermilab provides appropriate ES&H training as needed for hazards specific to the Fermilab site, e.g., radiation safety training.

MINOS Detectors

Qualification of personnel for work performed at collaborating institutions is stipulated in the MOU. This is especially important in regard to building the subsystems of the MINOS detectors. Task-specific training will be developed as needed, to be administered and documented by task leaders. This may include on-the-job training or mentoring. Training for jobs at collaborating institutions will be administered and documented in accordance with those institutions' own procedures. Safety and training records for laboratories and factories at collaborating institutions are maintained in accordance with the procedures of those institutions.

Soudan Experimental Hall

For the Soudan Underground Laboratory, training requirements are determined and records are maintained in accordance with the procedures of the University of Minnesota and the Minnesota DNR.

Criterion 3: Quality Improvement

It is the intent of the NuMI Project management that all activities for which it is responsible be performed at a level of quality appropriate to achieving the scientific, technical, operational, and administrative objectives in a cost-effective manner. The NuMI Project has established a variety of mechanisms for quality improvement. The project baseline is documented in the Technical Design Reports. A set of technical documents (NuMI Notes) is maintained electronically and is accessible to NuMI personnel and MINOS collaborators via the world-wide web. The status of the project is reviewed and changes are considered on a regular basis in several venues, as discussed in

the sections below. Reviews, assessments, value-engineering studies, and analyses by project personnel comprise a key component in continuous improvement of quality on the NuMI Project.

NuMI Beamline

Updates to the design of the beamline technical components are included in the NuMI Beam Design Handbook. The Fermilab NuMI Beam Group meets weekly to discuss progress and issues. Trends relating to costs, schedule and technical issues are analyzed and performance measures are established.

Updates to construction plans typically occur for Title I, Title II and following production, reflecting as-built conditions. Quality improvement mechanisms include meetings with subcontractors, weekly meetings of the NuMI Beam group and monthly meetings of the NuMI Environmental Coordination Group. The Environmental Coordination Group consists of members of the NuMI Project, the Fermilab ES&H Section and the Fermilab FESS. Its primary purpose is to ensure that the project is in compliance with applicable environmental regulations. In the event of ES&H concerns during contracted civil construction activities, stop-work authority rests with the Construction Coordinator.

MINOS Detectors

The prevention, control, and elimination of nonconformance with specifications are important aspects of quality improvement. Advanced Acquisition Plans (Procurement Plans) are developed for major subsystems of the NuMI Project to establish acceptable specifications, tolerances, and procedures for ensuring an appropriate level of quality and safety. The Advanced Acquisition Plans are maintained with this QA Plan as

supplemental documentation. Intermediate-level systems do not require an Advanced Acquisition Plan but may require separate QA procedures and documentation. A graded approach is applied in developing such documentation. Lower-level subsystems will typically have less formal documentation, but a strong emphasis on line management responsibility for identification and control of nonconformances is incorporated into the project. All project personnel are authorized to stop work in the event that a nonconformance presents an imminent threat to safety.

Each detector subsystem is subject to a series of performance and safety reviews, as described under Criterion 9: Management Assessment.

Soudan Experimental Hall

In addition to the performance reviews discussed for the MINOS project above, the Far Detector Hall to reviews by the University of Minnesota and the Minnesota DNR. For safety improvement, periodic drills of simulated emergencies are conducted. Such drills include Soudan Lab personnel, construction contractors and off-site emergency response personnel. The conduct of the drills are documented and analyzed and procedures revised or equipment augmented as found necessary.

Criterion 4: Documents and Records

The policy of the NuMI Project is to maintain adequate documentation and data to ensure that the quality requirements are met, while recognizing the objective of minimizing paperwork and administrative overhead. Controlled documents and data are created, implemented and maintained at a level commensurate with that of the work they describe.

NuMI issues monthly project reports, which are described in detail in the PMP. The monthly report receives contributions from all subproject managers at Levels 1, 2 and 3, as well as the ES&H and QA Coordinators. The NuMI Project Summary gives a less detailed overview of the project and is updated approximately every six months. The Monthly Reports and the Project Summary are uncontrolled documents for general distribution throughout the project.

Uncontrolled documents, including the project reports and the NuMI Summary updates, are generally released as NuMI Notes. Significant technical or scientific calculations, proposed design modifications, technical procedures, results of reviews and meetings, and other items of general interest to the project are also documented as NuMI notes and made available throughout the project. Each NuMI note is assigned a unique number and a set of paper copies is maintained at each collaborating institution. In addition to the paper copies, electronic copies are available on the world-wide web. The NuMI note website manager issues periodic updates of recently released NuMI Notes via electronic mail.

The NuMI Project maintains the following documents for project control (authorized personnel for each document are listed in parentheses).

1. NuMI Project Management Plan (NuMI Project Manager)
2. NuMI Facility Technical Design Report (NuMI Project Manager, NuMI Level 2 managers, NuMI Level 3 Managers)
3. NuMI Beam Design Handbook (WBS 1.1 Manager, Level 3 Managers)
4. MINOS Detectors Technical Design Report (NuMI Project Manager, MINOS Spokesman, MINOS Project Manager, MINOS Level 2 Managers)

5. MINOS Far Detector Laboratory Technical Design Report (NuMI Project Manager, Soudan Laboratory Manager)
6. NuMI Cost & Schedule Plan, with updates as published in the monthly report (NuMI Project Manager, NuMI Deputy Project Manager, MINOS Project Manager)
7. NuMI Quality Assurance Plan (NuMI Project Manager, NuMI Project Engineer, NuMI Quality Assurance Coordinator)

The NuMI Project also maintains the following documentation, which, while of narrower scope than the project control documents, are important to ensure quality in specific areas.

1. Memoranda of Understanding (NuMI Project Manager, affected Level 1 and Level 2 Managers, Principal Investigators)
2. Change Requests (Project Manager, Subproject Managers)
3. Internal Review Records (Level 1 Managers, ES&H Coordinator)

Documents and data pertaining to engineering specifications, engineering procedures, preliminary drawings, and documentation of subsystem design, assembly and testing are maintained as necessary by the appropriate subproject managers.

Specific elements or subsystems of the NuMI Project may require additional documentation or plans that include quality assurance procedures relevant to that element of the NuMI Project. Such documents will be referenced or incorporated into the NuMI QA Plan as appendices to this document. Records are maintained in accordance with the Fermilab Records Management Program.

Performance Criteria

Criterion 5: Work Processes

Work on the NuMI Project will be performed to the technical specifications set forth in the TDRs and the NuMI Beam Design Handbook. The administrative policies on the technical scope are set forth in the PMP. Work processes for specific subtasks are described in other documentation at a level of detail consistent with a graded approach to QA. The NuMI Project Manager and/or the NuMI subproject managers define the performance objectives. NuMI Project Management identifies criteria that define acceptable work performance and areas for improvement.

Work: General Objectives

The NuMI Project Manager's responsibilities as described in the PMP include administering, planning, organizing, and controlling the NuMI Project to meet the Project technical, cost and schedule objectives. In particular the NuMI Project Manager strives for effective human resource management with the goals of assembling and maintaining an efficient and effective work force. The individual NuMI worker is the first line in ensuring quality. People who are assigned to tasks have the appropriate academic qualification, professional certification, or skills and experience to carry out the work successfully.

In some cases, specific handling and storage procedures will be developed for items requiring special consideration. These are developed by the appropriate subproject managers and are documented as NuMI Notes, Advance Acquisition Plans or in another appropriate form.

NuMI Beamline

Work on the technical components of the beamline, including design, R&D, procurement of components, testing and installation, is done in accordance with standard Fermilab practices. These are described in the procedures for the Beams Division and of the other Divisions and Sections providing support for the NuMI Project. Work on the technical components performed offsite is done by qualified contractors or by institutions collaborating on MINOS through a MOU or similar document. The NuMI Beam Design Handbook provides a detailed description of the beam technical components. Traveler documentation noting their technical characteristics will accompany the beamline magnets and a database for the beamline cables will be established.

Control of items acquired by Fermilab, as well as recycled equipment belonging to Fermilab, will be achieved through the established procedures of the Fermilab Business Services Section. Control procedures for items that are provided by collaborating institutions are specified in the MOU. Calibration of measuring and testing equipment is performed according to Fermilab standards and procedures.

Civil construction and outfitting of the NuMI halls and tunnels on the Fermilab site is performed by qualified contractors selected through a process of competitive bidding. The contractor must provide Fermilab with an acceptable QA Plan. The Construction Coordinator is the primary point of contact between Fermilab and the contractor. Specifics of the interaction between the contractor and Fermilab management are documented elsewhere. [22, 23]

MINOS Detectors

Much of the work on the MINOS detectors, including design, R&D, procurement, assembly and testing of components is done at collaborating institutions or by MINOS collaborators using facilities at Fermilab. Details of the work to be performed, as well as the personnel and resources to be provided by each collaborator are specified in the MOU. Prototypes of equipment, including detectors and installation apparatus, and preliminary procedures for construction, installation and operation of MINOS are reviewed and tested in advance.

The MINOS database maintains a record of the construction history of the detector components and the state of the detector during its operating life. The database tracks the pertinent QA information for all important detector subsystems, as well as calibration information, subsystem modifications, replacement/repair histories, and environmental conditions. In the operational phase of MINOS, physical parameters, run numbers and other relevant experimental information will also be tracked. The database is described conceptually in Section 6.4.5 of the MINOS Detectors TDR. Updates and detailed descriptions are included in NuMI Notes as necessary.

Soudan Experimental Hall

Qualified contractors selected through a process of competitive bidding perform civil construction and outfitting of the MINOS Far Detector Hall at Soudan. The contractor must provide the University of Minnesota with an acceptable QA Plan.

Procedures for the installation of the MINOS Far Detector are under development. Mockups have been built and tested at Fermilab and processes have been tested through

the construction of prototypes. Appropriate procedures and training will be developed for the collaboration and minecrew personnel installing the detector.

Criterion 6: Design

Items and processes will be designed using sound engineering and scientific principles and appropriate standards as described in project documentation. The NuMI Cost & Schedule Plan identifies the activities associated with each element of the project. A WBS dictionary is found in the PMP. The NuMI Project Management Plan assigns the responsibilities for the implementation of these activities. Based on the PMP and the WBS, each subproject manager is responsible for planning the activities associated with their task(s).

Proposed changes to the baseline design are considered in appropriate design reviews, which include comparing them to the design inputs. Design changes that are recommended by the design reviews are then effected through the change control process as described in the PMP. Design controls are incorporated into the project using the configuration management process described in the PMP. Proposals for major design changes undergo a formal review commensurate with the magnitude of the proposed change. Modifications to the design are recommended when a review determines that the old design is inadequate or that the modification will produce performance and/or cost advantages.

Physics Program

The Fermilab Physics Advisory Committee (PAC) conducts periodic reviews of the laboratory's physics programs, including NuMI. This committee is comprised of senior

scientists from Fermilab, URA member institutions, and other high energy physics laboratories around the world. The PAC's report to the Fermilab director includes an assessment of progress on the project as well as recommendations for the physics goals of the project in the context of current developments in the high energy physics community world-wide.

NuMI Beam

Design inputs are based on the TDRs, the NuMI Beam Design Handbook and the experience and knowledge of the people involved. At appropriate stages of the design, major subsystems of the neutrino beam undergo reviews from qualified experts. Participants in such reviews include representatives of all functions concerned with the subsystem and may also include outside experts. The subsystem designs are also considered in a less formal manner by the MINOS collaboration at the collaboration meetings, which occur at approximate two-month intervals. These inputs ensure that the Beamline design meets appropriate physics and technical goals, as well as identifying potential problems in quality or safety. The Technical Design Reports and the NuMI Beam Design Handbook are the principal output of the design process and constitute the baseline design configuration.

The NuMI Radiation Safety Advisory Committee is made up of radiation safety experts from Fermilab and other accelerator laboratories. This committee meets on an as-needed basis to provide semi-formal reviews of NuMI radiation issues and proposed designs for shielding. The committee's review comments are provided to the NuMI Radiation Safety Coordinator and documented in the *Shielding Assessment for the NuMI Facility*. Final (sign-off) reviews of the beamline for ES&H considerations will be conducted in accordance with the FESHM.

NuMI Construction

Design drawings are issued for lab-wide review at three stages: 30%, 60% and 90% of completion. Comments from these lab-wide reviews are incorporated into the plans as appropriate to accommodate ES&H or QA considerations. Additional inputs come primarily from project personnel and subcontractors experienced in this work. Exhibit A[24] contains the terms and conditions for the subcontractors engaged in the civil construction for NuMI. Quality Assurance/Quality Control procedures are explained in this document in accordance with standard Fermilab procedures.[25, 26]

The NuMI Underground Advisory Board is composed of experienced consultants who work in conjunction with the Fermilab FESS and the NuMI Construction Manager. This board meets on an as-needed basis, but no less than bi-monthly, to review designs and provide comments. During construction, this group will conduct monthly walk-throughs to ensure that the construction specifications are met. Any design changes resulting from recommendations of the Underground Advisory Board are documented by FESS.

MINOS

Design inputs related to the physics goals may be related to optimizing the neutrino beam, the detectors, or both in response to physics results coming from other laboratories. As recommended by the High Energy Physics Advisory Panel[27], the NuMI Project maintains a degree of flexibility to explore the most promising avenues for new discoveries. The MINOS collaboration, through its regular meetings and its Executive Committee, ensures that the project is designed to achieve these goals. The Executive Committee may make recommendations regarding the design, upon which the project managers ultimately decide. Design outputs include the MINOS Detectors TDR, contractor drawings for outfitting the experimental halls, and relevant NuMI Notes.

The MINOS Project Manager in conjunction with the MINOS Level 2 (L2) Managers plans formal design reviews. These review committees are appointed and their charters prepared by the MINOS Project Manager, with advisement from the MINOS L2 Managers. Review categories include conceptual design reviews, interim reviews, and final (sign-off) reviews. Circumstances which may initiate a design review include when input from outside experts is needed, final sign off for a subsystem before production starts, or integration-related subjects which spans over more than one L2 project.

The Particle Physics Division has appointed the MINOS ES&H/QA Review Committee with the charge of making recommendations to the PPD Division Head on ES&H and QA matters as described in the committee's charter.[28] This committee conducts reviews of the experiment to address specific hazards vis-à-vis the FESHM and to identify QA aspects of the experiment which do not meet the laboratory's guidelines. The review process provides an independent verification that the formal approval chain has been followed.

Criterion 7: Procurement

The policy of the NuMI Project is to conduct all procurement activities such that all applicable scientific, technical, ES&H and quality requirements are fulfilled. Due to the fact that the NuMI Project is composed of collaborating institutions from around the world, minimal procurement requirements are explicitly stated in this document.

NuMI Beam

Generally, subproject managers are responsible for understanding and following the applicable procurement procedures for the materials and services being procured. In the

case of procurements made through Fermilab, prospective suppliers will be evaluated and selected in accordance with the procedures of the Fermilab Business Services Section (BSS).

All procurements for the NuMI Project, whether made through Fermilab or through a collaborating institution, are made in accordance with the specifications of the appropriate technical documentation, or, as necessary, additional technical reviews, to ensure a level of quality commensurate with project requirements. When appropriate, consideration is given to acquisition off-project of spares to ensure compatible quality. For critical goods and services, pre-qualification criteria are established before accepting bids from vendors or contractors. All procurements are subject to the inspection and acceptance testing processes discussed under Criterion 8.

NuMI Construction

Contracts for construction and outfitting of the MINOS caverns and halls, as well as for construction of the surface buildings, are let through a process of competitive bidding. Bids are reviewed by Fermilab's BSS and FESS sections as well as by senior project management and lab management. The Department of Energy reviews and approves the awarding of contracts as necessary. Factors considered when awarding construction contracts include the experience and safety records of the bidding contractors, as well as cost and quality issues.

MINOS

In general, collaborators follow the procurement procedures of their home institutions. Major subsystems are procured in accordance with Advanced Acquisition Plans prepared

by the appropriate subproject manager. Such Acquisition Plans will include criteria for the supplier, including costs, delivery schedules, technical specifications, ES&H considerations, and performance measures. The supplier is evaluated against these criteria and if quality problems are found, these are recorded and reported to the appropriate level of project management, who will then decide the disposition (i.e., accept, reject, re-work, etc.) of the procurement.

The formal agreement between the NuMI Project and collaborating institutions is the Memorandum of Understanding (MOU). This document details the scope of work, deliverables, the work schedule and funding arrangements for each institution's contribution to the project. The Memoranda of Understanding are described in more detail in Section 3.3.1 of the NuMI Project Management Plan. The MOU are amended and updated as necessary. Any changes to an MOU are approved by NuMI and Fermilab senior management as well as the principal investigator and administrative officer from the collaborating institution. The NuMI Project Management office maintains signed MOU and amendments.

Criterion 8: Inspection and Acceptance Testing

It is the policy of the NuMI Project to ensure that all items, components, and services meet appropriate technical specifications. This is verified through inspection and testing. The performance criteria of specified items, services and processes are generally established in the TDRs and in the NuMI Beam Design Handbook. For major subprojects requiring an Advance Acquisition Plan, testing procedures and acceptance criteria are specified therein. Examples are included in the references.

In general, subsystem managers specify particular measuring and testing needs, identify appropriate equipment for them, and maintain measurement records as necessary. In some cases they may also document maintenance and calibration data for such equipment, or such documentation might be maintained by a separate organization, e.g., the Fermilab ES&H Section maintains such documentation for radiation measuring devices at Fermilab. Where appropriate, equipment calibrations and maintenance procedures should be traceable to national or international standards (ANSI, NIST, ISO, e.g.). In keeping with a graded approach, testing procedures and documentation shall be commensurate with the level of precision and accuracy required for a given subsystem.

MINOS Detectors

Criteria for lower level subsystems, which do not require an Advance Acquisition Plan, are specified as necessary by the subproject manager. Factories at the various collaborating institutions fabricating components of the MINOS detectors conduct this work in accordance with procedures and acceptance criteria established and documented by the subproject manager. Inspections and acceptance tests are documented, specifying inspection techniques used, hold points and acceptance criteria. When appropriate, test results from components, prototypes, or subsystems are documented as NuMI Notes. Test results for specific detector components are tracked in the MINOS database.

Assessment Criteria

The following criteria describe how Quality Assurance is assessed in the NuMI Project.

Criterion 9: Management Assessment

In addition to the reports and meetings described in Section 4.1 of the PMP, managers will assess their management processes through scheduled reviews of the various subsystems.

NuMI Beamline

Performance reviews of the beamline technical components are conducted at Level 3 of the WBS. The NuMI Project Manager and the technical components subproject manager coordinate participation by technical experts from outside the project. These reviews are open to all MINOS collaborators.

The NuMI beamline will undergo review in accordance with the FESHM[29]. The Beams Division has established a safety review committee to review specific ES&H aspects of the NuMI beamline technical components in regard to design, construction and installation. In addition, the design considerations for radiation safety of the NuMI beamline have been extensively reviewed by a panel of qualified experts from within Fermilab and outside institutions.

MINOS Reviews

Performance reviews are conducted for each subsystem of the MINOS detectors. The MINOS Project Manager and the appropriate L2 manager coordinate participation by outside experts, obtain appropriate approvals for subsystems before production starts, and integrate work which spans over more than one L2 project. The review materials are sent to the reviewers one week in advance. The reviewers send their comments to the MINOS Project Manager within one week from the review date. MINOS performance reviews

are open to everyone in the collaboration. Any interested collaborators can attend and send their comments to the MINOS project manager.

Each subsystem undergoes a safety review in addition to the performance reviews. The NuMI ES&H Coordinator arranges these reviews with the appropriate MINOS managers, NuMI project management, the PPD and BD safety review committees, and the Fermilab ES&H Section as needed. The NuMI ES&H Coordinator maintains appropriate safety documentation resulting from these reviews for incorporation into the NuMI SAD.

Nominally, the MINOS reviews (performance and safety) fall into one of three categories:

- Conceptual design review
- Interim review (if needed)
- Final (sign-off) review

Advisory reviews may also be arranged upon the request of the L2 Manager.

Criterion 10: Independent Assessment

Independent assessments comprise a fundamental quality assurance process for the NuMI Project. Such assessments are conducted by groups of qualified individuals to assess progress on the NuMI Project. Independent assessments may focus on specific goals or seek to provide an overview of the project's overall status. The results of such assessments can help to identify problems, suggest solutions and provide for overall improvement. Examples of reviews that are conducted on a periodic basis are reviews by the Fermilab Physics Advisory Committee and semi-annual reviews by the Department of Energy. The Department of Energy will conduct a comprehensive review of the

project at intervals of approximately six months. The Fermilab Physics Advisory Committee conducts semi-annual reviews of the physics research program, including the MINOS experiment. Specific questions or concerns that the committee may have are addressed by the MINOS spokesperson.

Work at the Soudan Underground Laboratory is also subject to performance and safety reviews conducted by the University of Minnesota and the Minnesota Department of Natural Resources.

Some reviews may be less broad in scope, focusing on particular aspects of the project. Independent Design Reviews will assess the technical design of the various subsystems and are specifically provided for in the CSP. Furthermore, the NuMI Project Manager may initiate additional design reviews as appropriate.

Fermilab Reviews

The NuMI Project is subject to Fermilab's normal review processes. These include:

- Lab-wide construction reviews (30%, 60%, and 90%).
- Tri-partite ES&H Assessments (ES&H Section, BD/PPD, DOE).
- PPD Safety Reviews (Detector Components at Fermilab).
- BD Safety Review (Beamline).
- Radiation Shielding Assessments (Fermilab Radiological Control Organization as defined in the FRCM).
- Technical Reviews of detector and beamline subsystems (BD, PPD, MINOS, outside institutions).

The Fermilab Director may, at his discretion, call for additional reviews of the NuMI Project.

Reporting

The results of independent assessments are summarized in close out reports, which are distributed to project, laboratory and DOE management as appropriate. Summaries of major reviews are made available to the MINOS Collaboration at large and to Fermilab staff associated with the NuMI Project. Documentation related to such reviews is typically available in the form of NuMI Notes.

When independent contractors conduct an assessment of any aspect of the NuMI Project, the results are distributed to project staff whose work might be affected. For example, a life safety review and a value-engineering review by outside contractors were instrumental in developing the design of the NuMI Facility civil construction.

NuMI Quality Assurance Plan Revision History

Version	Date	Sections	Specifics
1.0	5/16/99	All	First Draft
2.4	5/8/00	All	Update for Spring 2000 DOE Review

Appendices

The following documents contain quality assurance procedures and criteria for specific elements of the NuMI Project.

Appendix A MINOS Steel

1. **Advanced Procurement Plan for MINOS Steel, October 28, 1998**

   This document includes a description of the quality assurance and handling procedures for the steel for the MINOS detectors.

2. **Quality Assurance Plan for MINOS Steel Acquisition, May 14, 1999**

   This document describes the Quality Assurance steps required to produce plates for the MINOS experiment meeting the specifications.

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